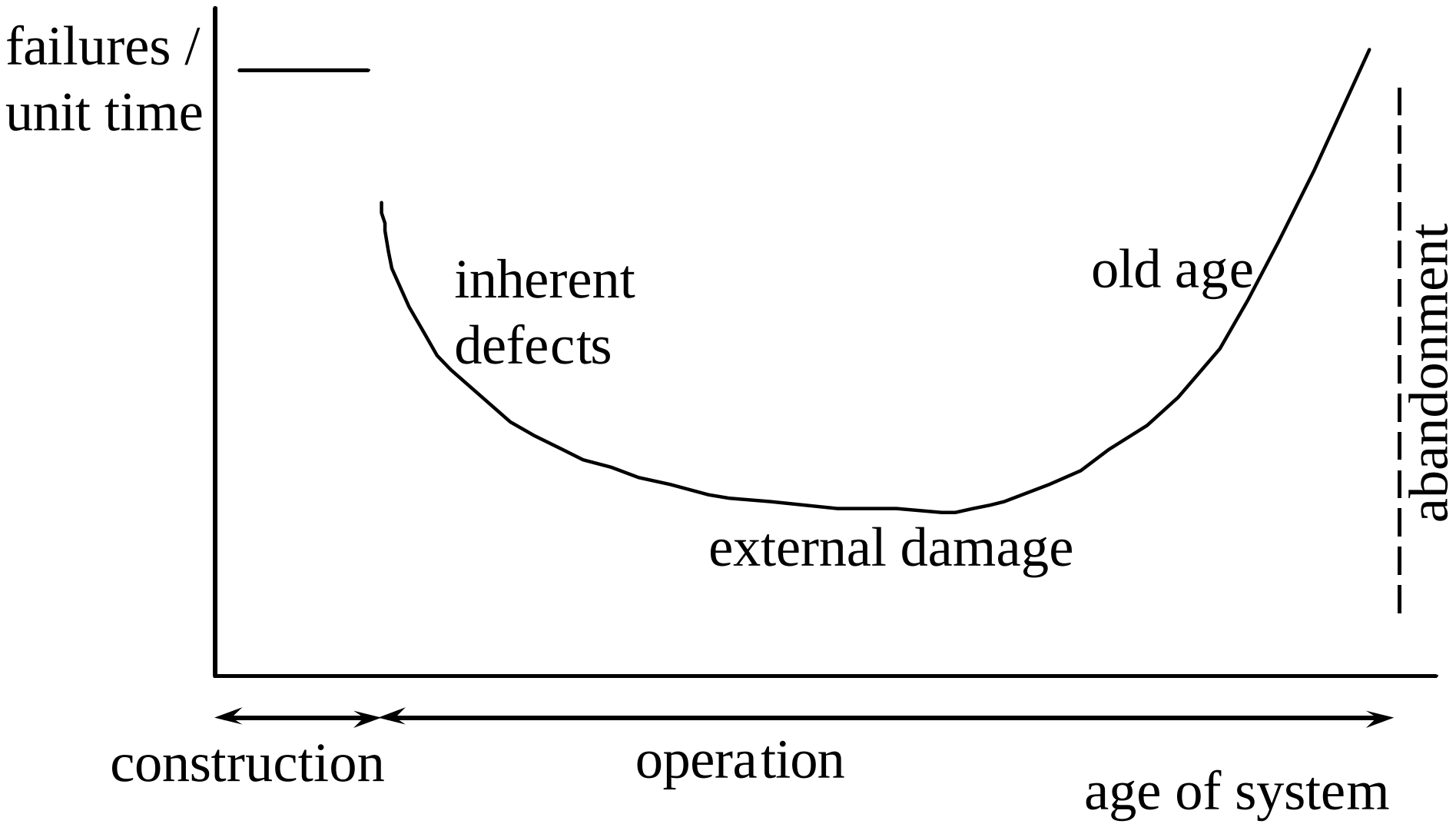
Challenges for Arctic offshore pipeline developments

Andrew Palmer

(Cambridge University)


failures /
unit time
inherent
defects
external damage
old age
abandonment
construction
operation
age of system

Problem areas

ice gouging

wave action

strudel scour

construction

Gouging

initial focus on gouge depth statistics

old idea: pipeline is safe if the ice passes over the top, not safe otherwise

therefore

problem is to determine extreme gouge depth, with some acceptable very low exceedance probability

Gouging

then it was realised that severe deformations occur in the soil under a gouging ice mass

a pipe is bent and distorted even if the ice clears over the top

subgouge deformations extend about another gouge depth below the gouge base, at least in some soils

Gouging

new idea: a pipeline is not necessarily safe if the ice passes over the top

therefore

problem is to determine trenching depth required so that pipe does not rupture, with some acceptable very low exceedance probability

Gouging

rupture allows the content to escape, and is the critical event

yield as such is irrelevant

fortunately, pipeline steels can be very ductile, and a pipe can be distorted a long way before it ruptures

trade-off between ductility and yield stress

weld ductility is the limiting factor

Gouging: outstanding problem areas

prediction of extent of subgouge deformations

influence of soil type

pipeline response

(analogy with landslides: theory and experience in Colombia)

Gouging: outstanding problem areas

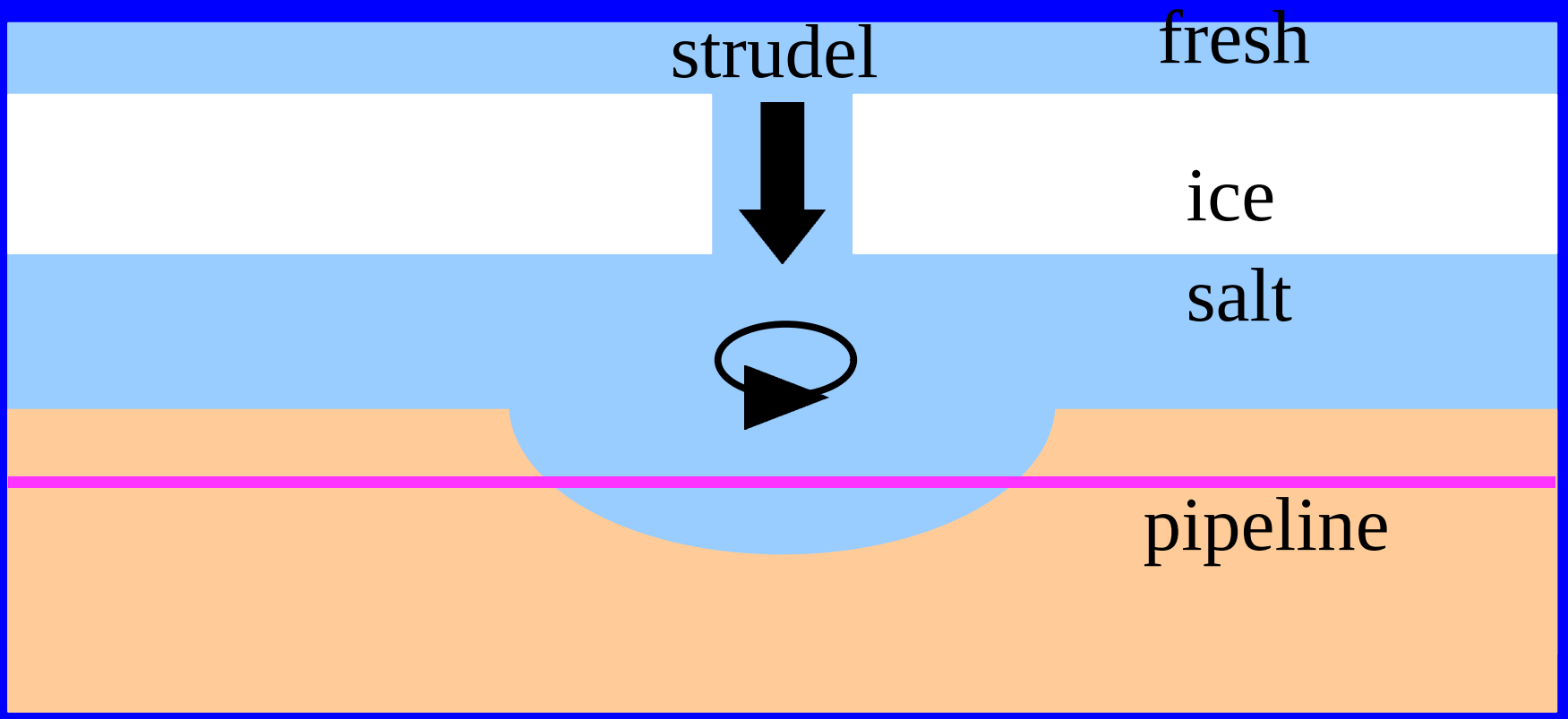
prediction of extent of subgouge deformations

influence of soil type

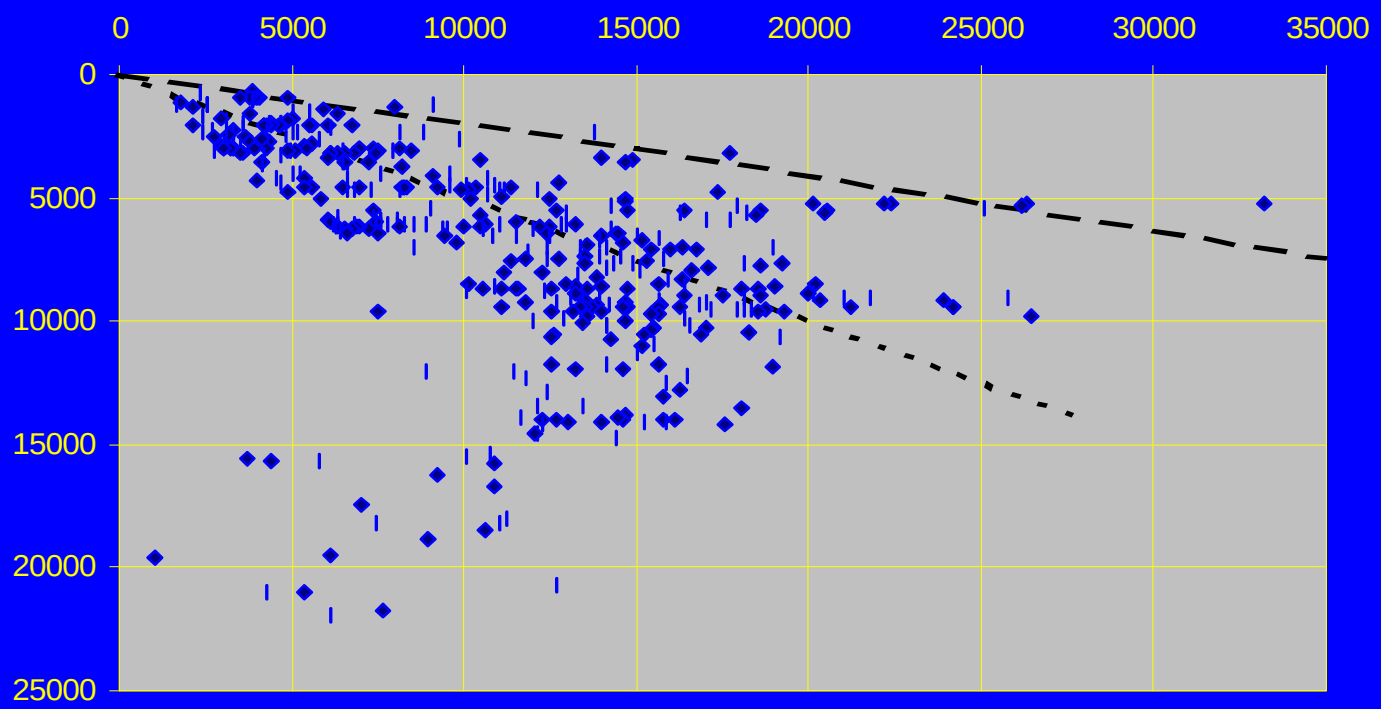
pipeline response

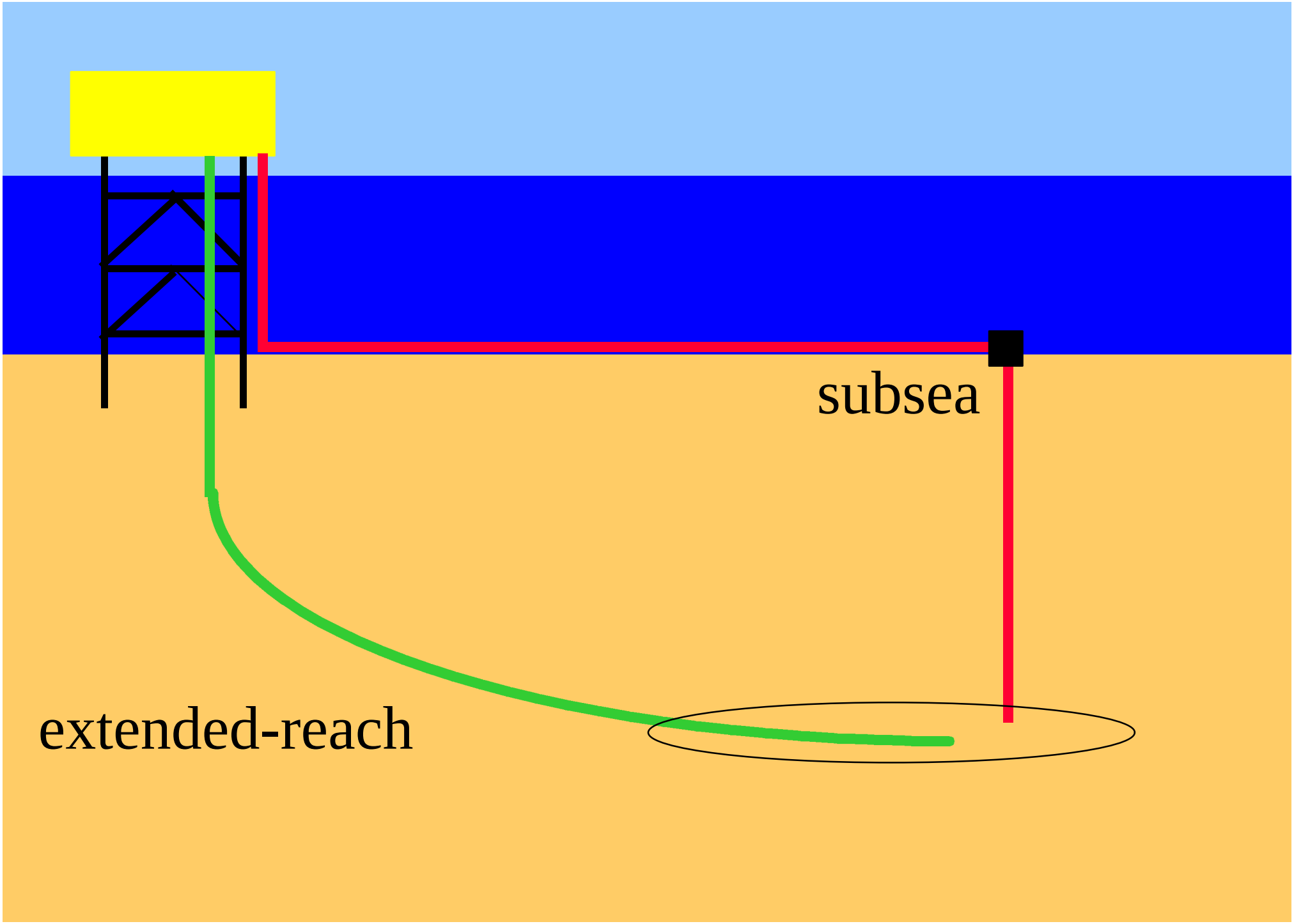
(analogy with landslides: theory and experience in Colombia)

Strudel scour

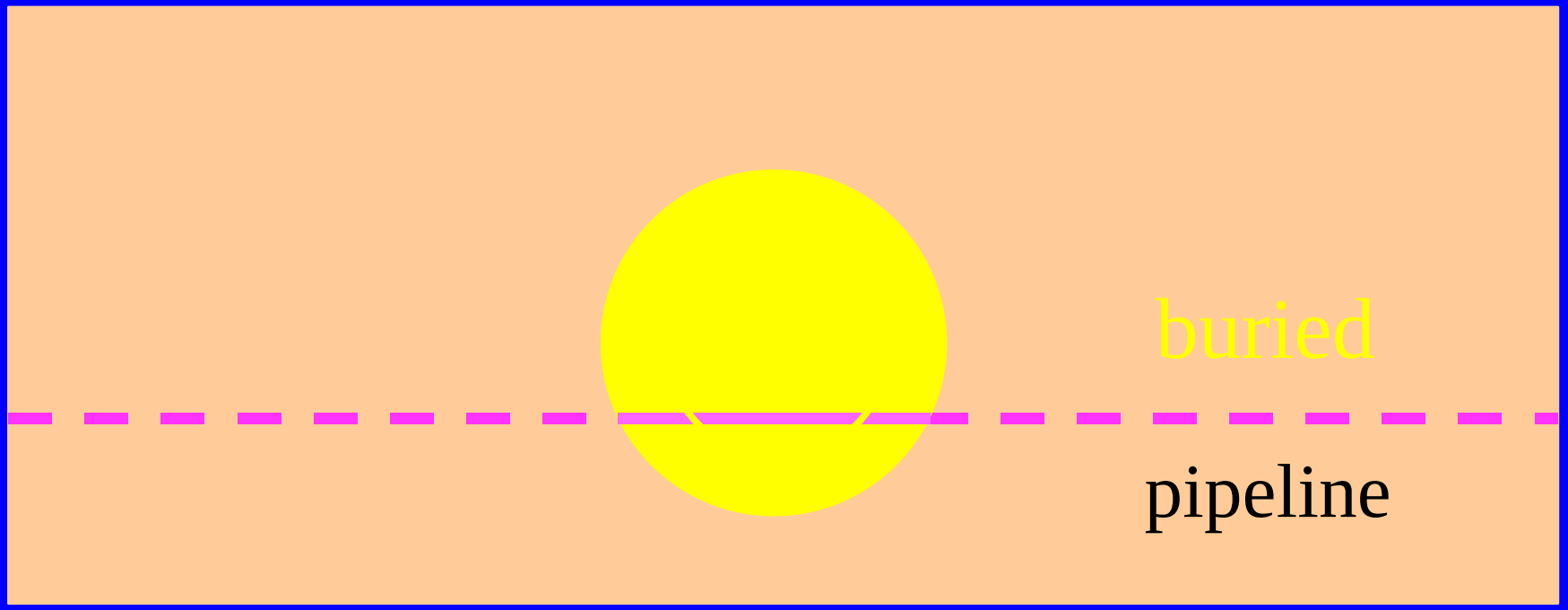


Industry Extended Reach Wells Drilled - to April 30th, 1998




subsea
extended-reach

Strudel scour



hydrodynamic drag

vortex-excited oscillation

construction issues

winter construction from ice

is the ice stable? sometimes yes (enclosed bays, lagoons) sometimes clearly no

major unceratianty about ice structural competence: super-brittle material (fracture toughness smaller than glass)

trenching issues

large trenches can be excavated by dredging

smaller trenches can be excavated by ploughing or jetting (or slowly by backhoe or dragline)

contractors cannot commit to develop equipment without some confidence that it will be used

horizontal/extended-reach drilling

- minimal environmental impact
- not weather-sensitive
- avoids shorelines
- as deep as necessary: therefore makes uncertainty about gouging and subgouge deformation irrelevant

horizontal/extended-reach drilling

- minimal environmental impact
- not weather-sensitive
- avoids shorelines
- as deep as necessary: therefore makes uncertainty about gouging and subgouge deformation irrelevant